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Abstract
Analyzing teachers' conceptions in 26 countries, our work identifies correlations between beliefs in creationism and in innatism, as well as correlations with strong believing in God, practising religion and some political opinions (anti-secularism, for a strong central power).
We used the questionnaire validated in the BIOHEAD-Citizen project and we added to the data collected by this project (in 18 countries) those then collected in 8 other countries. The sampling is the same in each country: 1/3 primary school teachers; 1/3 biology teachers in secondary schools; 1/3 language teachers in secondary schools; with, into each third, half of in-service and half of pre-service teachers.
There are very important differences among the countries, as well for conceptions related to evolution as for conceptions related to genetic determinism, showing interaction between science and society, and interaction between scientific knowledge, values and social practices. Less a country is economically developed, more teachers believe in God, in Creation and in Genetic Determinism.
These results are important to be considered when trying to improve biology teaching for more citizenship in primary and secondary schools, as well as in teachers' training.

Key-words: Evolution – Creationism – Genetic Determinism – Sexism – International survey – Teachers' conceptions -

Résumé
En analysant les conceptions d'enseignants dans 26 pays, notre travail identifie des corrélations entre les croyances créationnistes (anti-évolutionnistes) et la conviction que de nombreuses attitudes sociales seraient innées. L'ensemble de ces conceptions est lié à une foi en Dieu, à une pratique de la religion et à certaines opinions politiques (contre la laïcité, pour un pouvoir central fort).
Nous avons pour cela utilisé le questionnaire qui a été validé dans le projet BIOHEAD-Citizen, et nous avons ajouté 8 nouveaux pays aux 18 pays qui étaient impliqués dans ce projet. Les échantillons et protocoles de recueil de données sont identiques dans chaque pays, respectant un strict anonymat des réponses. L'échantillon comprend trois groupes : 1/3 enseignant dans le Primaire, 1/3 enseignant la biologie dans le Secondaire, et 1/3 enseignant la langue du pays dans le secondaire, avec, pour chacun des trois groupes, la moitié d'enseignants en service et l'autre moitié d'enseignants en fin de formation.
Les résultats montrent des différences très importantes d'un pays à un autre, aussi bien pour les conceptions sur l'évolution que pour celles sur le déterminisme génétique, illustrant des interactions entre science et société, entre connaissances scientifiques, valeurs et pratiques sociales. Globalement, moins un pays est développé sur le plan économique, plus ses enseignants croient en Dieu, dans la Création et dans le Déterminisme génétique.
Ces résultats sont importants à prendre en compte pour améliorer l'enseignement de la biologie et son articulation avec des valeurs plus citoyennes, aussi bien dans l'enseignement primaire que secondaire et pour la formation des professeurs.

Mots-clés : Evolution – Créationnisme – Déterminisme génétique – Sexisme – Enquête internationale – Conceptions des enseignants -

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1. Introduction and research question

The philosopher Canguilhem (1981) analyzed a reductionist trend in biology, reducing complex processes to a single molecular determinism. Is this reductionism still present when teaching biology?
It is more simple to consider the emergence of a new species as a project of God or of an intelligent design than considering the more complex evolutionary processes of differentiation (mutations, genetic drift) and natural selection today accepted by all the biologists, even when they are at the same time evolutionist and creationist. For instance, Dobzhanski wrote in his famous paper ("*Nothing in Biology Makes Sense Except in the Light of Evolution*", 1973): "*I am a creationist and an evolutionist. Evolution is God's, or Nature's, method of Creation*". The most important problem is the recent renewal of antievolutionary opinions, refusing to accept, to learn or even to teach, the scientific knowledge linked to evolution.

We explore here the possible link between antievolutionary conceptions and beliefs in genetic determinism as the only or main explanation of human features: the innatism. Several authors showed a link between innatism and intolerant attitudes as sexism or racism (Keller 2005, Dambrun et al. 2009, Ranger & Keller 2011, Castéra & Clément 2012). Other authors proposed an analogy between determinism by genes or by God (the genetic program as predestination: Nelkin & Lindee 1995, Clément & Forissier 2000, Kupiec & Sonigo 2001).

To analyze the possible correlation between conceptions related to creationism and to innatism, we did an international survey of teachers' conceptions, started in 18 countries by the BIOHEAD-Citizen research project (Biology, Health and Environmental Education for better Citizenship, 2004-2008, European Community CIT2-CT 2004-5006015) and then enlarged to 26 countries under the responsibility of Pierre Clément.
Some first results were already published for 1 to 19 countries only on the topic "evolution" (Clément & Quessada 2008, or only on the topic "genetic determinism" (Castéra & Clément 2009a, 2009b, 2009c, 2010, 2012).

The present paper is dealing with more countries than those involved in the BIOHEAD-Citizen project, and is analyzing for the first time correlations between creationism and innatism in teachers' conceptions from an international survey.
Are there differences among countries, showing interaction between science and society? Are there interactions between scientific knowledge (K), values (V) and social practices (P) (the KVP model proposed by Clément 2006, 2010)?

2. Methods

2.1- Questionnaire

We used the BIOHEAD-Citizen questionnaire, built and validated collectively (Clément & Carvalho 2007), dealing with six topics but we used here only the data related to two topics (evolution and genetic determinism) as well as personal information (gender, age, *etc*. including religious and political opinions). The main important items of the questionnaire can be read below within the results.

2.2- Sampling

We enlarged the initial sampling to the BIOHEAD-Citizen project (18 countries) adding 8 new countries: in Europe (Denmark, Sweden, Serbia, Georgia), in Africa (Burkina Faso and Cameroon) and in other continents (Brazil and Australia). The number of interviewed teachers is indicated for each country in the Figures 1 and 2, with a total of 9,422 teachers for the 26 countries.

The sampling is the same in each country: 1/3 primary school teachers; 1/3 biology teachers in secondary schools; 1/3 language teachers in secondary schools; with, into each third, half of in-service and half of pre-service teachers.

2.3- Data analysis

The questionnaires were filled out with a total guaranty of anonymity, in presence of the researcher who immediately collected the filled questionnaires. More details are presented in Clément & Carvalho (2007).

The data were then put in Excel files and analysed in France with several kinds of multivariate analyses. Computations were performed mainly with the statistical software "R" with the multivariate analysis package ade4 (Munoz et al 2007, 2009, Castéra & Clément 2012).

3. Results and discussion

A Co-Inertia analysis (Dray et al. 2003) shows a clear correlation between the two PCA (Principal Components Analysis) done from two sets of variables:

(1) The 14 items related to evolution / creation + the 31 items related to biological determinism and

(2) The 13 items concerning personal information including political or religious opinions.

A Monte Carlo test (Romesburg 1985) shows that these correlations are very significant ($p<0.0001$).

The most correlated items are:

Creationist conceptions:

- B48 – Importance of God in species evolution (Likert's scale with 4 boxes)
- A64 – Origin of life (ticking one from four items: cf. legend of Figure 1)
- B28 – Origin of humankind (same choice as in question A64)
- A62 – Choice of 3 expressions among 6 (3 being linked to evolution, 3 to creation)
- B29a & B29b – *"Theory of Evolution (or Creationism) contradicts my own beliefs"*
- B42 – No importance of chance in species evolution (4 boxes between *"no important"* to *"very important")*
- B43 – No importance of natural selection in species evolution (4 boxes idem B42)
- A33 – Disagree with *"The emergence of the human species (Homo sapiens) was just as improbable as the emergence of any other species"*.

These creationist conceptions are also correlated with belief in the genetic determinism of gender inequality or ethnic inequality or sexual preferences:

- A35 – *"Ethnic groups are genetically different and that is why some are superior to others"* (Likert's scale with 4 boxes between *"I agree"* and *"I disagree").*
- A38 – *"It is for biological reasons that women more often than men take care of housekeeping"* (idem: the same Likert's scale as in A35)
- A46 – *"Biologically, men cannot be as sensitive and emotional as women"* (idem)

- A25 – *"It is for biological reasons that women cannot hold positions of as high responsibility as men can"* (idem)
- A41 – *"Homosexual couples should have the same rights as heterosexual couples"* (idem)

The co-inertia analysis shows that all the precedent conceptions are correlated with some religious or political opinions:

- P12b – Practising religion (five boxes between *"I practice"* and *"I don't practice"*)
- P12a – Believing in God (five boxes between *"I believe"* and *"I don't believe"*)
- A51 – Disagree with *"Science and religion should be separated"* (Likert's scale with 4 boxes between *"I agree"* and *"I disagree").*
- A37 – Disagree with *"Religion and politics should be separated"* (idem).
- A42 – Agree with *"Only a strong central power can put some order in my country"* (idem).
- A34 – Agree with *"The government must make laws favouring the creation of firms to stimulate our economy"* (idem).

In brief, creationist conceptions are correlated to belief in biological determinism (justifying inequalities among human beings: gender, ethnic groups, homophobia, called *"intolerant attitudes"* by Keller 2005) and also with high level of believing in God, practising religion and with anti-secularist (anti-*"laïcité")* positions and with some other political positions. Evolutionist conceptions are correlated with opposite personal beliefs and opinions.

These results show two contrasted systems of conceptions (as defined by Clément 2010), each pole being characterized by KVP interactions: K (knowledge) more actual for evolutionism, linked to V (values) and P (social practices) more tolerant, promoting human rights; while creationist conceptions are linked to out-dated K and with V and P more conservative and more fatalist.

In consequence, teaching evolution and human genetics can be more complex and difficult than often expected and needs coordinated pedagogical strategies for several topics of biology.

The Figures 1 and 2 illustrate the teachers' answers to two questions, country by country, showing for each question very important differences among the countries.

Related to evolution (A64, on origin of life, Figure 1), ticking one of the two first items shows clearly evolutionist conceptions, ticking the third item: creationist and evolutionist conceptions; and ticking the item 4: radical creationist conceptions. This item 4 was chosen by about 2% of teachers in Denmark, France, Sweden and Estonia, but by more than 80% of teachers in Algeria and Morocco, including most of the biology teachers, and between 50% and 75% in Senegal, Lebanon, Tunisia, Cameroon, Georgia, Romania and Burkina Faso.
In other countries, the amount of the radical creationist answer is lower than 10%, or 15% in Italy and Finland), except in Malta, Poland, Brazil and Cyprus where it is between 25 and 35%. An important point is the relatively great amount of teachers ticking the item 3 (red in the Figure 1) showing both creationist and evolutionist conception, probably the same as expressed by Dobzhanski in 1973 (see above). In the European countries (with the exception of Romania and Georgia) as well as in Australia and Brazil, more teachers ticked this item 3 (evolutionist and creationist) than the item 4 (radical creationist).

These results are confirming those already published (as in Clément & Quessada 2008, 2009), showing a strong correlation between the amount of creationist conceptions and the high level of believing in God and practising religion, as well as with the low economical level of the country. We can shortly comment the results from the 8 new countries which were not implied in the BIOHEAD-Citizen project:

- **Denmark and Sweden** were chosen to have other Scandinavian countries than only Finland, the three being mainly Protestant (Lutherian) but with also an important amount of atheist/ agnostic in Denmark and Sweden. Their teachers are the most evolutionist of our sampling, with France and Estonia where about half of the teachers said to be atheist or agnostic, the other being Protestant in Estonia or Catholic in France. These results illustrate than Christian teachers, being Protestant or Catholic, are clearly evolutionist in some countries.
- **Serbia and Georgia** were chosen to have more teachers of the Orthodox religion, to compare them with the Orthodox teachers of Cyprus and Romania. The figure 1 shows strong differences among these four countries, the amount of radical creationist teachers (ticking the item 4 or the question A64) being 11% in Serbia, but 54% in Georgia, not far from Romania, Cyprus being in the middle of these two poles. This result clearly illustrate the strong influence of the national socio-cultural context, that cannot be reduced to the confession, most of the teachers of these four countries saying that they are Orthodox (71% in Romania, 77% in Cyprus, 88% in Serbia, 100% in Georgia).
- **Burkina Faso and Cameroon** were chosen because a large part of the interviewed teachers were Christian (77% in Cameroon, 64% in Burkina Faso), while in the other African countries of our sampling most or all the teachers are Muslim (89% in Senegal, 97% in Morocco, 92% in Algeria and 96% in Tunisia). The Figure 1 shows a large amount of creationist conceptions in all these African countries, with a little less amount in Burkina and Cameroon. Nevertheless, when comparing the Muslim and Christian teachers in Burkina Faso, the Muslim teachers (25% of our sampling) are a little less creationist than their Christian colleagues. Here also, our results show strong differences among African countries, that cannot be reduced to the dominant religion, nevertheless with an important convergence: the high amount of creationist conceptions.
- **Brazil and Australia** were chosen to enlarge our sampling to other continents than Europe, Africa and Middle East. In Brazil, 1/3 of the interviewed teachers are clearly evolutionist, 1/3 are at the same time evolutionist and creationist, and 1/3 are radical creationist (including evangelist confessions). In Australia, 52% of the interviewed teachers are clearly evolutionist, and 12% are radical creationist, a little less than in Italy. We will discuss these results in detail in a future publication.

Related to biological justification of a gender inequality (A38: taking care of housekeeping, Figure 2), 2% of French teachers were agreeing or rather agreeing, less than 10% in Italy, Portugal and Sweden, while more than 70% in Algeria, more than 50% in Morocco, Lebanon, Lithuania, Senegal.

The results related to 23 of these 26 countries are discussed in detail in an other publication (Castéra & Clément 2012): only Georgia, Serbia and Sweden were missing. In Sweden 12% of teachers agreed or rather agreed with this biological justification, while 22% in Serbia and 39% in Georgia.

We don(t discuss more these results here, focusing the last part of the discussion on the correlation between teachers' conceptions related to creationism and to innatism.

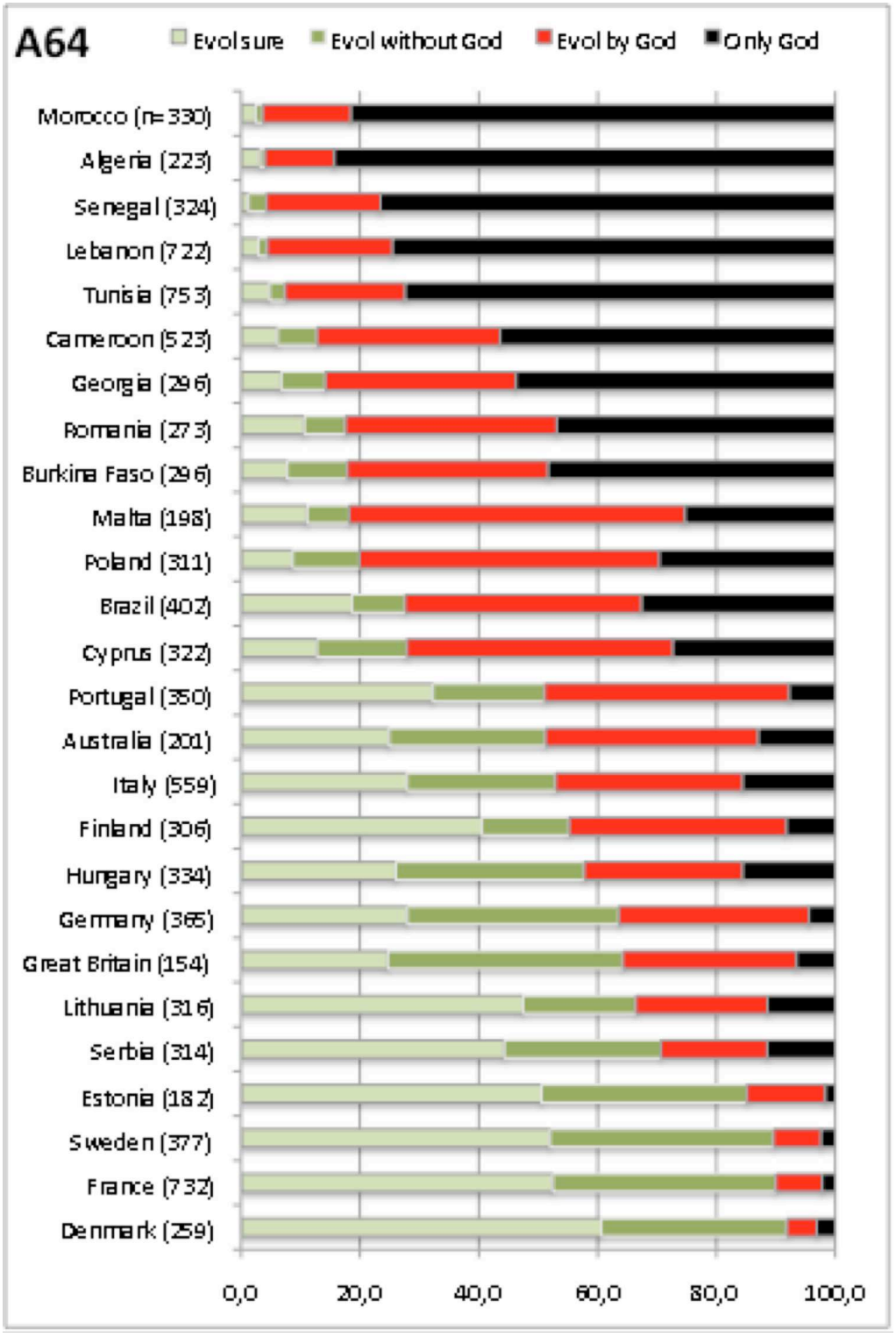

Figure 1. Teachers' answers, grouped by country, to the question A64:

A64. **Which of the following four statements do you agree with the most ?** (tick only **ONE** answer)

☐ It is certain that the origin of life resulted from natural phenomena.

☐ The origin of life may be explained by natural phenomena without considering the hypothesis that God created life.

☐ The origin of life may be explained by natural phenomena that are governed by God.

☐ It is certain that God created life.

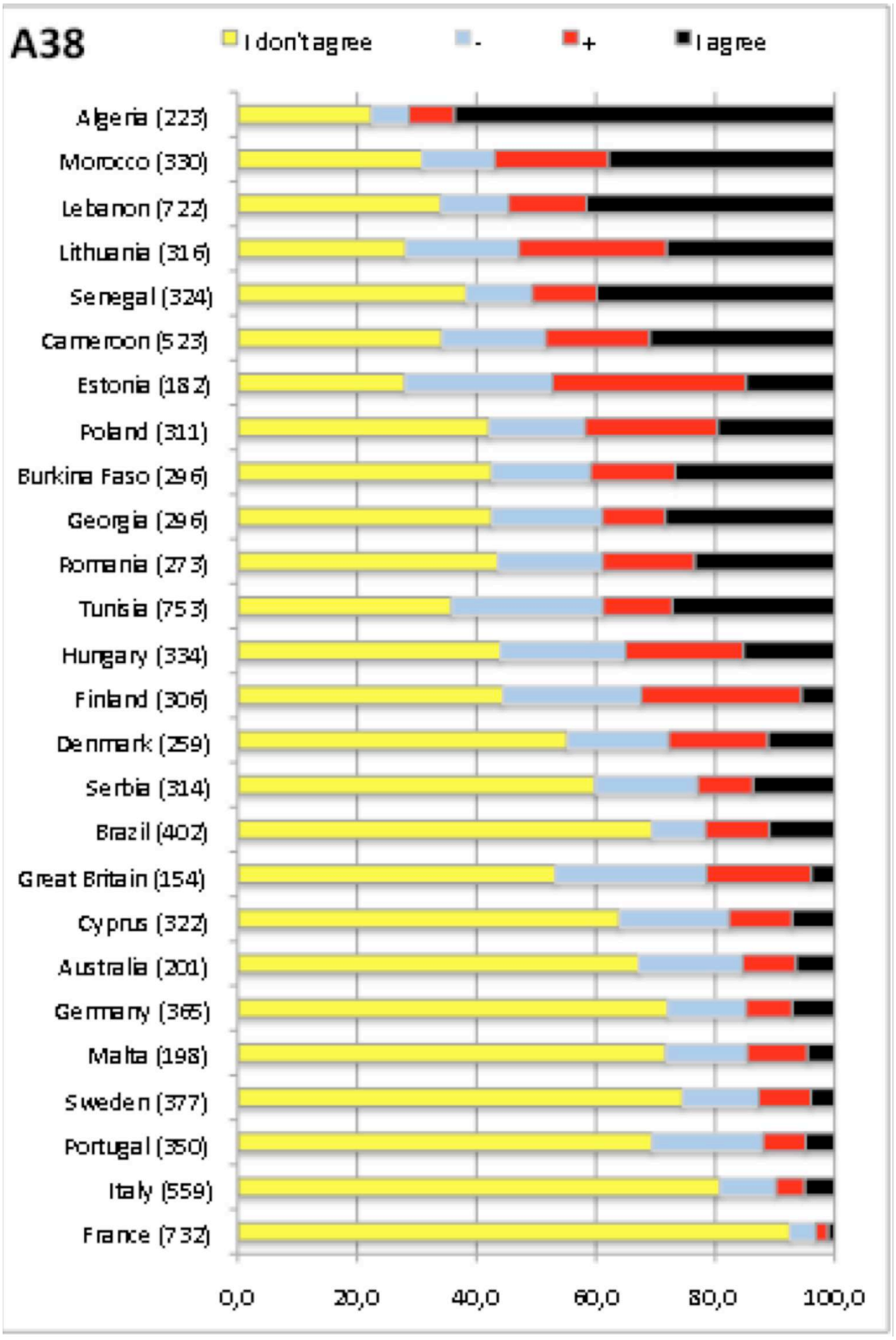

Figure 2. Teachers' answers, grouped by country, to the question A38:

A38 – It is for biological reasons that women more often than men take care of housekeeping

I don't agree | | | | | **I agree**

Globally, the ranking of countries is nearly the same for the two questions A64 (Figure 1) and A38 (Figure 2). There are some interesting exceptions, that can also be observed when looking at this type of histogram for each of the 19 correlated variables listed above. For instance in Estonia and in Lithuania, most of the teachers are clearly evolutionist (figure 1) while nearly half of them agree or rather agree with a biological justification of housekeeping by women (figure 2).

Nevertheless, the analysis country by country globally shows a clear trend, statistically significant: less a country is economically developed, more the interviewed teachers believe in God, practice religion and have creationist conceptions and a large part of them have a strong belief in genetic determinism justifying intolerant attitudes as inequalities among gender, ethnic groups or sexual preferences.

While biology, as any science, claims to be universal, while all the biologists consider evolution as a pillar for understanding of biological processes, while no result of any research showed the suspected existence of a gene of housekeeping, it is surprising to see the large amount of teachers, in several countries all around the world, referring more to God than to evolution when thinking to the origin of life or of humankind, and referring to a biological justification of housekeeping for women only.
The scientific knowledge (K) of these teachers is strongly interacting with their social practices (P), justifying these practices by updated scientific knowledge while they are in fact rooted in their values (V). These values need to be identified: fatalism is a value which justifies the acceptation of non citizenship attitudes, as sexism, racism or homophobia. The universal human rights are alternative values, with a legal equality of all the human beings among their gender or ethnic differences, or their sexual preferences.
As shown by Canguilhem (1981) and other authors mentioned in the introduction of this paper, reductionism can be a dangerous ideology in biology, reducing the complexity of any biological process to only one single cause, as a gene or as God. When teaching biology, it is important to be aware of this danger.

When analysing teachers' conceptions on evolution and on genetic determinism, our results show strong KVP interactions (between scientific knowledge, values and social practices), characterizing opposite systems of conceptions, rooted in systems of values and social practices claiming to be justified by scientific knowledge. These two opposite systems of values are more or less present in each of the 26 countries of our sampling, but one of them can be strongly dominant because it is rooted in the socio-cultural context of the country, including its history, its economical level, its dominant religion, etc.

Introducing the analysis of KVP interaction when training biology teachers is an important goal to help teachers to be less prisoners of their own system of conceptions, and to be aware about the danger of reductionism (even if it is often useful to start to teach single more than complex processes).
Kochkar (2007) also showed that, when a teacher introduced more up-dated knowledge as cerebral epigenesis and epigenetics, his students (last year of secondary school in Tunisia) changed their conceptions to more tolerant attitudes.

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